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The What, Where and Why of Orthopaedic Simulation

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It's no longer blood and gut, it's bits and bytes [1]

The collaboration between hospitals and industries has been underpinned for several years. The relationship between medical staff and healthcare providers is established especially in the pharmaceutical, medical products, surgical instruments, and scanner. Today with the challenges in orthopaedics [2], we need to create a bridge between orthopedists and professors in university to produce a new strategy of education using 3D simulation. This concept is defined as an object representation with an easier model to study. Flight simulators are best known compared to other simulators for training learners [3]. The realization of medical simulators becomes possible with a contribution of new technologies. Using 3D simulation, as a part of training methodology, has several advantages including cost-minimizing. The simulation allows the construction and the reconstruction of models already used. In addition, the level of details provided by 3D images is possible. For example, learning endoscopic techniques can be done in different ways, such as a mannequin. This technique can be more or less realistic and allows to get used to the handling of instruments and to the practice of simple gestures such as suturing. The main drawback lies in its lack of realism. The objective of 3D simulation is to demonstrate the competence and confidence, as well as reducing the risk of errors when used on patients. In addition, simulation can save a lot of money for surgical trainees in the operating room. This has been estimated at US $ 53 million per year [4].

In 2010, Mabrey et al. [5] mentioned 23 articles for orthopaedic surgery compared with 246 citations for laparoscopic simulators. Most of these provide a complete training experience for students. Today with the technological advances of virtual reality, we can evaluate the competency of students. It is important to see the reactions of the student facing unexpected situation. 3D simulation helps students to practice surgery in the less expensive and the most harmless way ever been. With 3D simulation, the curriculum of future surgeons will include some features such as: (1) approved level of difficulty, (2) repetitive practice, (3) rigorous, (4) precise educational measures, and (5) engaged with well-defined objectives. Moreover, 3D simulation can help to improve the quality of the patients' consultation. Orthopaedic surgeons diagnose debilitating osteoarthritis and prescribe magnetic resonance examination. The NMR [6] is realized according to a specific protocol in the department of radiology which confirms the indication and analyze the hip, the knee and the patient's ankle. These three joints allow the construction of the mechanical axis of the patient's leg. This axis is required in order to implant the prosthesis correctly. The results of NMR help to achieve a 3D simulation on the computer (virtual images of the anatomy (bone and cartilage) of the patient). 3D models help surgeons to prepare virtually for their intervention on real patients and to determine the positioning and the exact size of the prosthesis. 3D analysis of the patient's anatomy and reconstruction assistance with the same parameters improves clinical results.

Building an effective simulation requires a certain understanding of the simulated task. The following criteria should be readily verified in order to guarantee a correct level of reliability:

* Simulations should allow the consolidation of new skills within a defined curriculum that ensures good training.

* Simulations should map onto real practice.

* Simulation should motivate students to learn.

Designing of orthopaedic simulation is not an easy task. Many steps must be analyzed and planned in detail using computer simulation. 3D anatomy of bone and tissue must be reconstructed based on Computed Tomography (CT) images [7]. Many applications are mentioned in literature, including custom artificial joint replacements, bone allograft and osteotomy surgery. In fact, more years are needed to reach both the maturity and the efficiency desired by surgeons. We can cite HipMotion [8] which aim to perform a 3D Kinematical analysis of hip joint based on Computed Tomography (CT). It is possible to assess the ROM and specify the site at which FAI would occur. The limitation of this software is cited in [9].

Generally, the validation of a teaching tool is a difficult task, especially orthopaedic simulation. There is no clear consensus yet in the literature on the evaluation of simulation. Different validation strategies have been proposed by the American Association like the American Psychological Association (APA) [10]. It must be recalled that the design of a surgical simulator is based on two concepts which are surgical training and assessment of surgical skills. The validation is performed in the presence of a surgeon which discusses with his students the feedback of simulation. Today, we mentioned the development of metric [11] that can allow simulators to be autonomous. For that purpose, we need to rethink our validation's concepts to avoid wasting time and to improve proficiency. The question arises: is it possible to apply the surgical validation's model in orthopaedics? We need to redefine our strategy of simulation to change the training of orthopedists.

To conclude, 3D simulation has great potential to facilitate learning in orthopaedic surgery, further refinements are on the way.

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Students need opportunities for regular, deliberate practice. For that purpose, surgical skills should be repeated in simulation. We would caution scientists to focus on the development of realistic simulations, in order to improve the quality of training.

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